



Smart Buildings

Combining energy efficiency, flexibility and comfort

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White papers for a green transition

SMART BUILDINGS

Combining energy efficiency, flexibility and comfort

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Thinking smart in the design phase

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SMART BUILDINGS

Combining energy efficiency, flexibility and comfort
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A EUROPEAN ENERGY REVOLUTION

A triple-win Energy Strategy - benefiting the economy, the society and the environment



Maroš Šefčovič
Vice President of the European
Commission for the Energy Union

We are in the midst of a revolution. The industrialised world which is highly dependent on a secure supply of energy at competitive prices has reached a breaking point. We in Europe now realise that our energy supply is dependent on external factors we cannot control and that the traditional modes of energy production, based on fossil fuels, have created the greatest threat lurking human kind: climate change.

The European Commission has therefore made it a top priority to revolutionise Europe's energy market, ensuring it is secure, competitive and sustainable. One of the most effective measures for reducing both the energy price and its environmental footprint is very simply to consume less.

We call it the 'Efficiency First' principle, where we make sure that efficiency and demand side response can compete on equal terms with generation capacity. In other words, before seeking new energy sources we must ask ourselves if added energy is

really necessary; if there is no way we can do without. The EU as a whole has committed itself to improve its energy efficiency by at least 27% by 2030.

This ambitious target obliges all of us to work together; decision-makers and entrepreneurs, researchers and financial institutions. For its part, the Commission will take a series of measures in order to facilitate this transition. These include facilitating the access to finances when it comes to innovative efficiency projects, putting forward a Heating and Cooling Strategy for buildings (where the saving potential is tremendous), a Circular Economy Package which will address our resources consumption with a more holistic approach, and of course the promotion of research and innovation of new technologies.

For all the above reasons, I warmly welcome the Danish white paper, showcasing pioneering projects, from across Europe, which found creative ways to be more energy-efficient.

The solutions you have highlighted manifest, once again, that energy efficiency provides Europe's industry with an unparalleled business opportunity. I have often said that the Energy Union was a triple-win Strategy, benefiting the economy, society, and the environment. In your work - you exemplify that! I therefore encourage you to continue. I have no doubt that together we can make Europe the most energy-efficient continent.

Yours,

Maroš Šefčovič

ABOUT THIS WHITE PAPER

In Denmark as well as in many other countries, fluctuating renewable energy resources account for an increasing share of power generation. The green transition requires enhanced focus on energy consumption and the ability to shift demand to hours where there is more wind and solar power in the energy system. Buildings account for up to 40% of society's energy demand and thereby play a key role in the green transition. Their design and function define our private and work lives. By building smarter it is possible to achieve greater energy savings, flexibility and comfort to the benefit of people and the climate.

The aim of this White Paper is to share best practice on Smart Buildings that offer more flexibility, comfort and energy efficiency. Through several state-of-the-art case examples, the White Paper illustrates the potentials and lessons learned on how to maximise the outcome of implementing smart systems in buildings through innovative architecture, construction, technology, management and user-behaviour.

The White Paper is a tool for inspiration to spot the potential and promote or implement building automation and energy-efficient measures in new and existing buildings globally.

The potential of smart buildings extend beyond the buildings themselves when they play their role as flexible components in a diverse energy system that offers still larger amounts of fluctuating energy sources. The cases presented in this White Paper are examples of buildings that hold the potential needed for energy efficiency and flexibility to be integrated in the intelligent energy system of tomorrow.

We hope you will be inspired.

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Increasingly global questions. Denmark has quite a few answers

BUILDING AUTOMATION - PROVIDING DATA FOR BUSINESS OPPORTUNITIES

Building technologies impact the bigger picture

Building automation is going to be an even more important component of the smart energy agenda and a provider of important data for business development.

Assoc. Prof. Alfred Heller, Deputy Leader of CITIES (Center for IT-intelligent Energy Systems for Cities), researcher in smart cities, building technologies in combination with data management, big data and Internet of Things.

Trends within building automation

Building automation has been known in some building types for centuries. It has traditionally been driven by a demand for security, comfort and economic benefits. In recent years, the remarkable share of total energy consumption by buildings (around 35-40%), has played a more significant role in the global energy and climate agenda. This has been a new driver for increased application of building automation.

All over the world buildings have a large potential to reduce their total share of energy consumption, while at the same time maintain and improve their indoor environment and comfort. Building automation is a key technology in this regard.

Buildings and building automation are also important elements in future demand response markets which gradually emerge. The thermal mass of buildings is "for free" and can constitute a very large potential for flexibility. Depending on conditions, buildings are able to contribute with up to few days of energy shifting in time. This potential could be optimised in the future by increased automation and revised designs.

Basically, this tendency is based on the experiences with Thermo-Active Building Systems (TABS) constructions that will be further developed in the coming period. If buildings' flexibility should play a role as a reserve in a demand response energy market, it is important that building automation is designed for that purpose.

The use and provision of data

Modern, smart buildings are data consumers, utilising external data sources such as weather data and energy price data in their predictive control strategies. In the near future we will also see control systems that will use signals from mobile devices, e.g. the calendar of the home owners to predict their presence and thereby demands for comfort. This allows the system to regulate the energy consumption outside the comfort range while the residents are absent, thereby enabling increased flexibility. Big companies like Google and Microsoft and small innovators have already discovered the huge business potentials of these kinds of services.

Building automation could also provide a lot of data to the surrounding smart energy

sector and thereby contribute to the global trend of making data a basic resource of the modern industries' business development opportunities.

Data appears from the extensive monitoring equipment, which is a precondition for building automation. Monolithic Building Management Systems (BMS) and Energy Management Systems (EMS) that dominate current technology will probably have to make room for more adaptive technologies in the very near future.

A single well-equipped, modern office building can easily supply data from 10,000 sensors with high-frequency data, and thereby contribute to the Internet of Things' global trend, if data is made available. This opens up a future where smart buildings and building automation deliver data to new and still unknown markets.



THE WORLD'S SECOND-LARGEST BUILDING IS PACKED WITH GREEN TECHNOLOGY

Danfoss products are contributing to making Shanghai Tower a world-class green building

Shanghai Tower is the tallest structure in China and the second-tallest in the world.

Mette Uhd, Senior Project Manager, Danfoss Corporate Communications & Reputation Management

The Shanghai Tower stands 632 metres tall as the tallest structure in China and the second-tallest building in the world. In 2013, Danfoss won several orders for Shanghai Tower, including one for 6,700 valves to help control the skyscraper's cooling and heating systems. This is the biggest order for this type of valve that Danfoss has ever supplied for a single building.

Danfoss products help make Shanghai Tower a world-class green building. The structure has already earned the American LEED* Gold certification and the Chinese "Green Building Three Star" rating, which is the highest standard achievable in China.

Kilometres of pipework

The 6,700 control valves save more than 20% of the energy used by the cooling and heating systems, compared to normal control valves. They automatically ensure

precise control and the right balancing of the water flow in the building's kilometres of pipes. This also means that people on the top floor get the temperature they want, when they want it, regardless of the temperatures preferred on lower floors.

"The heating, ventilation and air conditioning system accounts for more than 50% of the building's energy consumption. Our control valves can cut this energy consumption by 20%, and that means a lot to the owner," says Danfoss sales engineer Lu Guosheng, who was in charge of the project.

Danfoss also delivered 660 variable speed drives for the heating and cooling systems. They ensure that the pumps, compressors and fans never run faster than necessary to ensure the right temperature, providing additional savings to the tune of 20-40%. Moreover, the energy efficiency of the air

conditioning system is boosted by pressure transmitters and filter dryers, likewise sourced from Danfoss.

With integrated cooling, heating and power supply, buildings like Shanghai Tower provide huge opportunities to help meet the need for energy demand-response in next generation energy systems.

Facts about Shanghai Tower:

- The 121-floor building is 632 meters tall and has a total floor space of 576,000 m² containing a hotel, offices, retail and cultural facilities, and observation decks at the top.
- Construction finished in November 2015.
- On completion, the tower became the second-tallest building in the world, after the Burj Khalifa in Dubai.

Shanghai Tower is the tallest building in China and the second-largest in the world. It complies with the strictest environmental requirements – and Danfoss technology will help achieve that. (Photo: Danfoss)

* Leadership in Energy and Environmental Design (LEED) is a set of rating systems developed by the U.S. Green Building Council (USGBC) for the design, construction, operation and maintenance of green buildings, homes and neighbourhoods.

COWI LEARNS FROM OWN FLEXIBLE KNX SOLUTION

An ultra-modern building that puts energy optimisation and comfort in focus

Consultant engineering firm COWI in North Jutland moved into one of its own projects constructed with a flexible and open KNX (Konnex) installation, and learned more about the energy-efficient solutions they provide for others.

Pelle Fischer-Nielsen, PR Manager, Schneider Electric

Engineers from COWI had a taste of their own medicine when they moved into one of their own building projects on a former industrial estate in Aalborg, Denmark. The focus on energy efficiency and flexibility in the technical installations means that COWI's engineers are now experiencing the benefits of premises that have become the setting for their vision of tomorrow's sustainable building development.

The intelligent heart

The heart of the building is the KNX installation, which was developed in close collaboration with Bravida Danmark A/S and KNX specialist, Schneider Electric. The installation has provided the consultant engineers with a living, architectural gem that is full of inspiration.

"The whole concept of the building is that people bring the building to life as it wakes from its energy-saving hibernation whenever movement and readings show a need for ventilation, light and temperature regulation. The 650 KNX components make the building behaviour-controlled, which provides a comfortable indoor climate while keeping energy consumption at a minimum. The intelligent KNX installation can easily be adjusted and linked to the buildings

management system making the building ready for the future of advanced energy management and demand response," explains Rene Aaholm, Head of Section at COWI in North Jutland, who helped develop the concept.

Every day, the intelligent building forms the workplace for around 200 employees, who can follow the building's indoor climate and energy consumption easily via info screens. These displays encourage users to maintain an energy-efficient behaviour.

"Visionshuset is an ultra-modern building, where all of the functions have been included in a sustainable cycle so that energy optimisation and comfort are in focus. In the actual technical rooms, we have chosen to use a traditional Building Management System (BMS) for controlling ventilation and heating systems, but as soon as you enter the offices, it is the KNX installation that controls all of the lights and climate conditions. The two systems have been integrated via an Open Platform Communication (OPC) server, which gives the customer a complete graphical interface with a display of all the technical points in the building," explains Jørgen E. Sørensen, District Manager at Bravida.

Visionary installation

Visionshuset now reigns over the old fibre-cement site in the heart of Aalborg, and is proof of a special project where COWI was the project manager for all the engineering disciplines.

"We are delighted with the implementation of the KNX installation, where we have gained some positive experiences. Our customers can benefit from these and from this very efficient and flexible system, which by using relatively simple measures, creates intelligent buildings that add value in several areas. Often KNX installations lead to better indoor climates and less energy consumption without users feeling any change to their daily comfort," says Rene Aaholm.

KNX is an open protocol with numerous components, which can be easily combined and provide countless options for optimising comfort, energy consumption and indoor climate in a single system. The integration between KNX, HVAC and BMS systems is seamless and easily handled via a gateway.

KNX provides both energy savings and a good indoor climate at Visionshuset on the old fibre-cement site in Aalborg where the modern sustainable premises form the setting for COWI's innovative planning of the green buildings of the future. (Photo: Schneider Electric)



Architecture: KPF Arkitekter

GREEN PARTNERSHIP GIVES HOSPITAL MAJOR SAVINGS

Shared savings as part of energy performance services

Schneider Electric and Private Hospital Heart Center Varde have entered a partnership that follows a "shared savings" model, which will yield energy savings of almost EUR 140,000.

Pelle Fischer-Nielsen, PR Manager, Schneider Electric

Anything you want to achieve usually comes at a price, also when it comes to energy savings. But occasionally it is neither difficult, costly or in any other way risky to reap the benefits of lower energy costs. Private Hospital Heart Center Varde found the answer in a close partnership with Schneider Electric, who takes the risk of the project.

"In just a short time we have managed to reduce our energy consumption significantly. Just like other companies, we want to act responsibly towards our environment, and we would of course also like to run a company with a healthy bottom line. The project with Schneider Electric benefits both the environment and the hospital's finances," says Ricardo Sanchez, CEO and Chief Surgeon at Private Hospital Heart Center Varde.

Shared savings: Reduce risk and save money for customers

The hospital is one of the first companies in Denmark to enter an energy-saving partnership with Schneider Electric that follows the so-called "shared savings" model. As the name suggests, the model is about sharing any savings made. The entire risk falls on Schneider Electric and represents a completely new way of approaching energy savings.

The hospital's Building Management System (BMS) is remotely monitored, gathering and analysing data and then changing the relevant parameters for the building's operation.

"Shared savings is a new offer within our Energy Performance Services, and we see major potential for the model. It is suitable for numerous companies, as they will not have any implementation risks. The company does not need to contribute with any investments - however we share any savings equally between us," says Bo Johansson, manager of the Schneider Electric's Remote Operation Center.

Savings of almost EUR 140,000

In 2010, Private Hospital Heart Center Varde moved into new, modern buildings measuring a total of 5,300 m². Already during the first three months of the agreement, the hospital has saved almost EUR 7,000. Over the five-year agreement period, the total savings are expected to reach almost EUR 140,000.

Schneider Electric's specialists optimised a number of operational parameters and controls in the hospital's BMS system, e.g.

changed the ventilation systems into a more need-driven operation, made automatic adjustments to ensure the lowest possible flow temperature in the heating systems, and regularly optimise room temperatures, air quantities and CO₂ levels.

All adjustments have been made with maximum regard for comfort for both patients and staff, and of course for the special requirements that a modern hospital with surgical wards has for operational reliability.



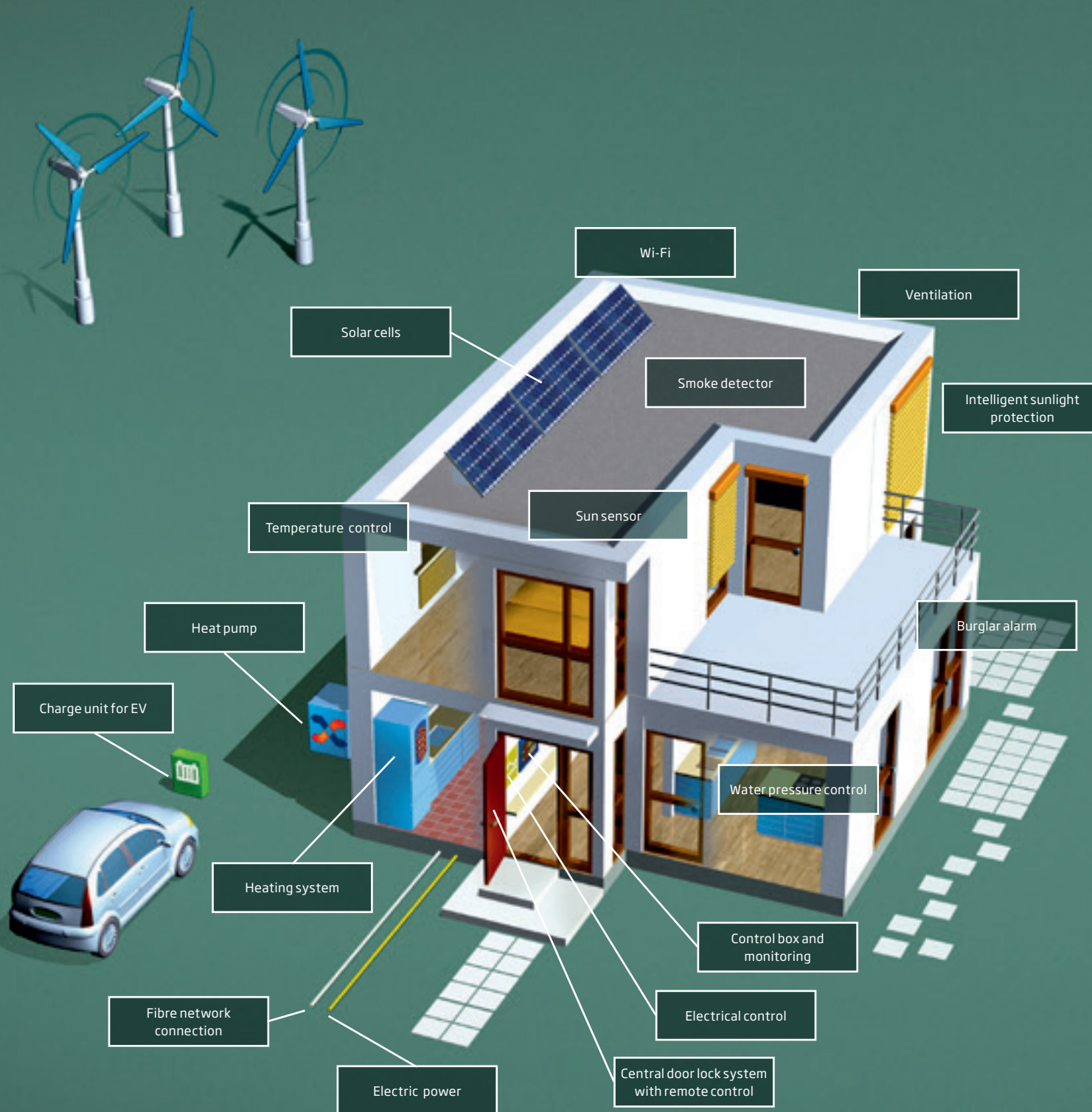
Photo Credits: Private Hospital Heart Center Varde

SMART BUILDINGS

Automation makes buildings a flexible part of the energy system

Renewable energy resources account for an increasing amount of our power generation. The demand side needs to adapt by enhancing flexibility on the demand side. Smart buildings are part of the answer.

Managing Director Helle Juhler-Verdoner, The Danish Intelligent Energy Alliance



Meeting ambitious renewable energy and CO₂ targets

Denmark and our neighbouring countries have decided to implement ambitious renewable energy targets as well as CO₂ targets by 2020 and 2050. EU has set a target at 27% renewable energy in 2030. The renewable target is a part of the goal to reduce Europe's CO₂ emission by 80% in 2050 compared to 1990 levels.

Today, wind power's share of the Danish power generation already accounts for almost 40%, which is why Denmark has a strong focus at enhancing flexibility in the demand of electricity. Compared to earlier day's traditional power generation this implies a major change. We can no longer turn the power generation on and off the way we used to do, as we are relying on the wind and sun to a larger extent.

The logical reply to this is enhanced focus on the demand side through electrification that offers demand-side flexibility. What is lost in control on the production side can be gained on the demand side by enabling remote monitoring of electricity consumption in

buildings, e.g. for heating, cooling, lighting and ventilation.

Remote monitoring systems

Many buildings are already equipped with some sort of monitoring system: Energy Management System (EMS), Konnex (KNX), Building Management System (BMS) or similar systems. The systems are also established with the purpose of delivering a large variety of service on light, air quality, heating and cooling and to optimise energy consumption in terms of energy savings and energy efficiency. Therefore, demand-side flexibility is about applying what is already installed for the purpose of using electricity flexibly, when it is wind-based and therefore cheaper.

Improving the business case

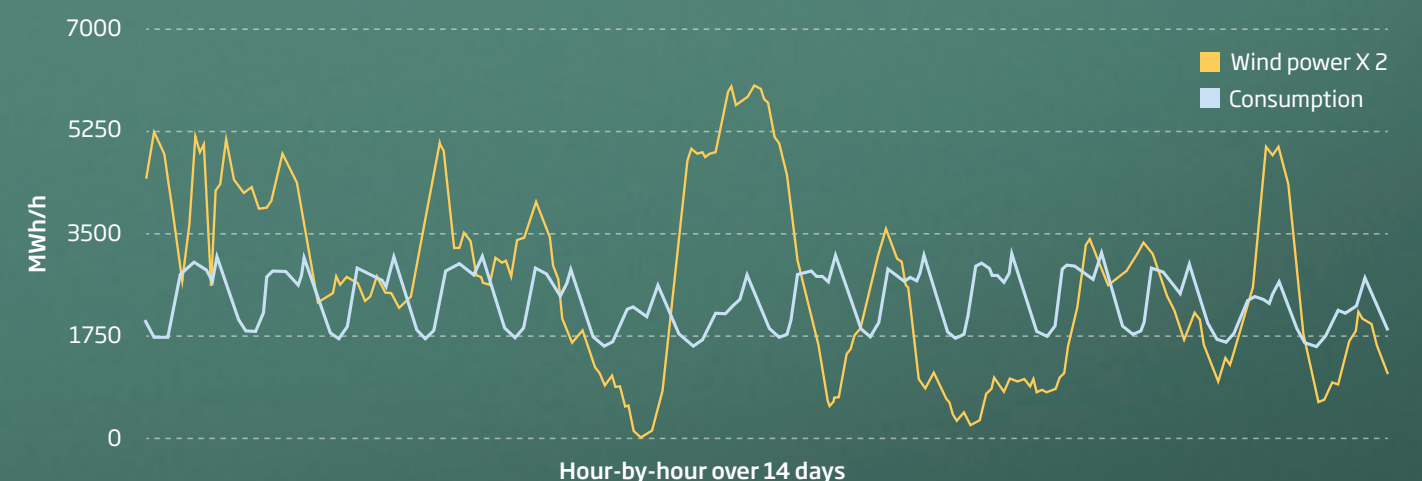
Combining energy savings and energy flexibility in new or renovated buildings can be done at a minimum investment level. Investing in energy flexibility can improve the combined business case and ensure that buildings are smart grid ready. In the near future, we will see more price peaks. When differences in the electricity price

over the 24-hour period become more significant than they are today, flexible buildings are ready to benefit from this development, without significant additional investment costs.

Rewarding flexibility

Denmark has decided to implement a number of important policy decisions to ensure that all consumers, including owners of larger buildings, can benefit from the flexibility. Especially the decision to implement smart meters is fundamental and will lead to hourly based billings of all consumers towards 2020.

Other elements in the market must be changed to support the business case for demand response. This includes new market rules in the electricity markets, so that flexibility can be offered into the market on equal terms with power generation. Likewise, building codes and regulation of buildings' energy performance should be changed, not only to require energy efficiency in buildings, but also to require energy flexibility to be part of the building code going forward.



Balancing electricity consumption with increasing shares of wind power - Getting ready for "the new reality"

The graph demonstrates power consumption in Denmark held up against increasing fluctuating wind power generation, hour-by-hour during 14 days of the autumn 2013. The horizontal axis begins on Monday at 0:00h. Typically, the lowest level of consumption is at 03:00h in the night. To illustrate the increasing challenge of balancing the energy system towards 2020 and beyond, the 2013-level of wind power during those 14 days has been doubled in the graph. The point is that gaps between consumption and power generation will increase - part of the solution must be delivered by demand response in buildings to assist in balancing the system (Source: Energinet.dk and Danish Energy Association)

UN CITY, COPENHAGEN

The future of sustainable buildings

“UN City is an example of how modern, energy-efficient offices can play their part in building the future we want.” - Ban Ki-moon

Eva Egesborg Hansen, Public Diplomacy and Communications Adviser, UN City Copenhagen

UN City, located at the tip of Marble Pier, is the first new building in the heart of the Northern Harbour - the new waterfront city district in Copenhagen. The area is being transformed from an industrial port into a modern residential and business quarter with a focus on sustainability and smart energy systems.

UN City provides office facilities for 1,500 UN employees in the UN organisations in Copenhagen under one roof. It is a state-of-the-art building in the field of energy efficiency and climate friendliness.

The architects at 3XN, along with Orbicon, have designed the building. They have worked to comply with international environmental standards and regulations. As the focus was on the needs and values of the UN, the work plan was developed according to more than 1000 specifications of the UN's demands for the building. The user-driven innovative aspects have ensured

that UN City meets the UN's demands for its new headquarters in Copenhagen.

UN City functions as an energy-efficient building with a calculated energy consumption of less than 50 kWh/m²/year. In 2012, UN City was awarded the European Commission's Green Building Award for New Buildings. UN City is the first UN complex to receive the LEED Platinum Certificate (see page 8 for description).

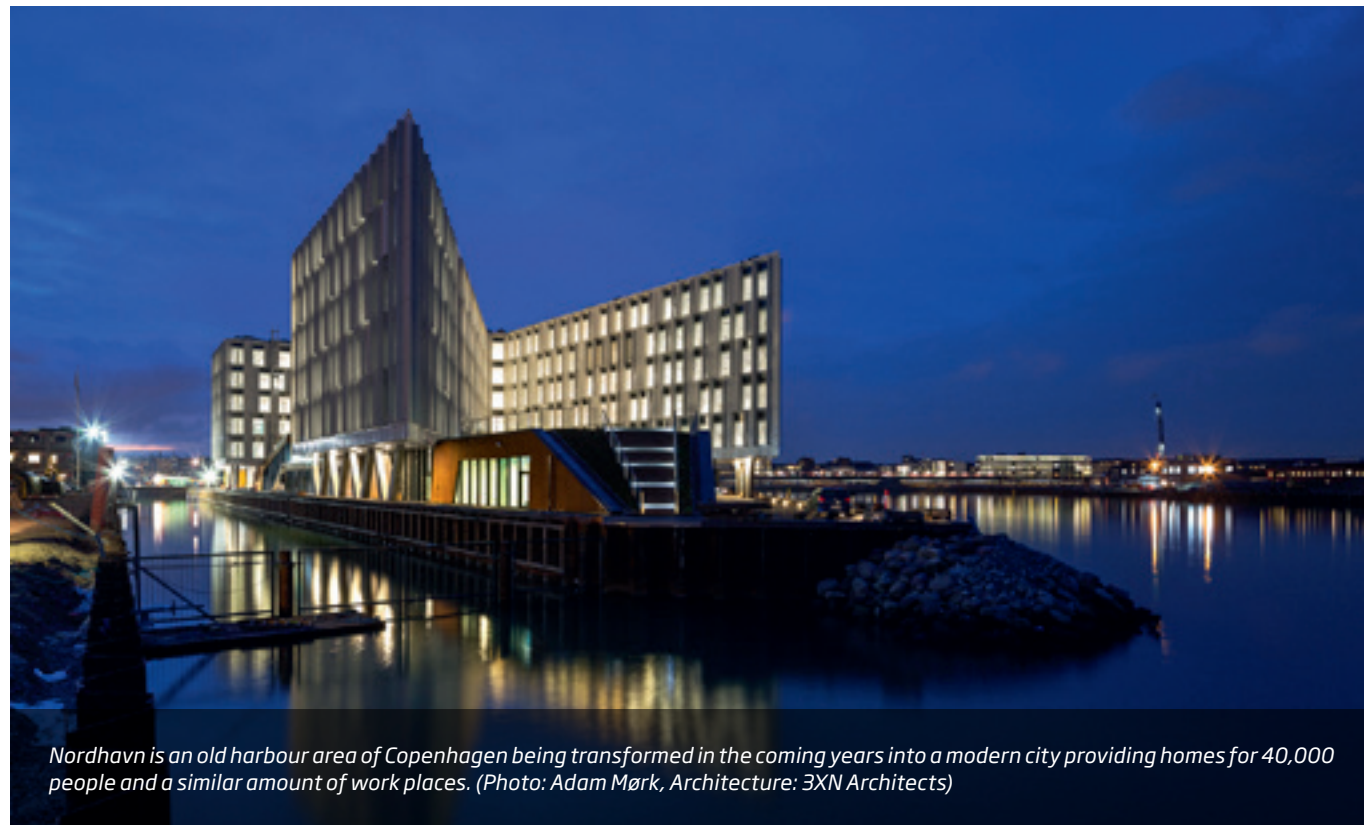
UN City - sustainable in many ways

Thinking green was also at the top of the agenda during the building process of UN City. All materials used for the building were transported less than 800 km to reduce energy use and CO₂ emission.

UN City has been designed to use at least 55% less energy than similar-sized office buildings. The need for energy is reduced through the adaptation of eco-friendly features that cut the need for energy used on heating, cooling, lighting and ventilation.

Sophisticated solar shades on the building's façade can be opened and closed to either trap or reflect heat from the sun. UN City is entirely ventilated with filtered outside air, and heat exchangers are pumping cold seawater through to cool down the building. More than 1,400 solar panels are placed on the roof of the building equalling electric savings of 30%. The roof has been made by a white, recyclable membrane made from plant-based materials. The environmentally-friendly coating reflects sunlight and reduces the solar warming of the building.

Lastly, approximately 3 million litres of rainwater are collected annually, which is enough to flush the building's toilets an estimated 5,300 times each day. Combined, low flow taps and toilets and the usage of rainwater reduce the consumption of water by 60%.



Nordhavn is an old harbour area of Copenhagen being transformed in the coming years into a modern city providing homes for 40,000 people and a similar amount of work places. (Photo: Adam Mørk, Architecture: 3XN Architects)

ENERGYLAB NORDHAVN

New urban energy infrastructures

From 2015 to 2019 EnergyLab Nordhavn will develop and demonstrate future energy solutions in the urban development area Nordhavn in Copenhagen.

Birgitte Torntoft, Senior Communication Consultant, ABB A/S

The project utilises a full-scale smart city energy lab and demonstrates how electricity and heating, energy-efficient buildings and electric transport can be integrated into an intelligent, flexible and optimised energy system. The project contributes to the grand challenge of transforming the energy system to efficiently integrate a large share of renewable energy - a means to support international and national climate goals.

The project focuses on the cost-effective, smart energy system of tomorrow that integrates multiple energy infrastructures (electricity, thermal, and transportation) and provides an intelligent control of

subsystems and components - providing necessary energy flexibility for efficient utilisation of renewable energy.

One of the participants is ABB, who aims at developing an energy system where demand and supply equilibrium is achieved in a "smart" and sustainable way.

Data will be collected from private residents and businesses, and the consumers will be given the opportunity to automatically control lighting, ventilation and heating, as well as allowing an aggregator to externally control and thereby support a future demand response market.

"We are working on a model that makes it attractive to take part in a demand response market. Our system should make it easy for consumers to follow energy supply and prices and to select the cheapest energy source available at a given time. For ABB it is important that our experiences in Copenhagen give us know-how that we can use all over the world", says Dorthe B. Schow, Communications- and Marketing Director in ABB Denmark.

In relation to this lighthouse project, it is relevant to make reference to another Danish lighthouse project at the Danish island Bornholm, The Eco Grid EU project, which demonstrates interesting demand response results. For more information on the results from the project please consult the website: www.ecogridbornholm.dk



Photo: By & Havn / Ole Malling Architecture: COBE & SLETH

SUPERMARKET KEEPS NEIGHBOURS WARM WITH SURPLUS HEAT

CO₂ refrigeration system saves energy and leads surplus heat into the district heating network

“There is a huge untapped potential worldwide for refrigeration systems to become an integrated part of distributed district heating networks. The systems become suppliers of energy”, says Danfoss engineer Torben Green.

Trine Kiar, Communication Advisor, Danfoss Cooling Segment

The supermarket chain SuperBrugsen in Høruphav, Denmark, does not only supply fresh groceries to the local residents. It also supplies heat. The supermarket has been equipped with an innovative CO₂ refrigeration system that keeps food fresh, provides the entire store with a constant source of heating and delivers energy savings. Additionally, all surplus heat is channeled into the district heating network for the benefit of residents living close by.

Supplies 16 private homes with heat

“Calculations show that the surplus heat from SuperBrugsen will supply 16 standard homes of 130 m² annually with environmentally-friendly district heating,” says Jan Due Christensen, Department Head, Sønderborg District Heating.

“Based on the political objectives of phasing out fossil fuels and utilising renewable energy and surplus energy sources to a greater extent, district heating will play a key role for the urban energy systems of the future,” says head of development Jan Eric Thorsen, Danfoss Heating.



Saves money and reduces CO₂ emissions

SuperBrugsen in Høruphav already saves more than EUR 26,800 a year on gas and reduces CO₂ emissions by 34% by utilising the surplus heat from the refrigeration system to heat tap water for cleaning.

“There is a huge untapped potential not only in Denmark, but worldwide, for facilities with large refrigeration systems to become an integrated part of distributed district heating networks. They shift from being consumers of energy to also being suppliers of energy,” says Danfoss engineer Torben Green. The case is therefore a good example of energy flexibility across energy sectors such as heating and electricity.

In principle, all supermarkets located near a district heating supplier can supply heat from the refrigeration system to residents nearby. The solution in Høruphav has been developed in cooperation with Kellmanns VVS & Blik, Vojens Køleteknik, Sønderborg District Heating, CLEAN, and Danfoss. The investment's payback time is just 12 months.

The business case for connecting supermarkets with electricity and heating networks stems from energy and CO₂ savings and very short payback times for the supermarket owner.

Demand response potential

Supermarkets also provide excellent opportunities to help meet the need for energy demand response in next generation energy systems.

Local district energy networks are very effective to balance fluctuating supply from renewable energy, like wind and sun, to meet the demand of electricity during peak load. They can act as storage facility to provide the required demand response. Supermarkets as ‘virtual power plants’ utilise the flexibility in the cooling demand and other electricity consuming activities like defrosting.

The full potential of adding the flexibility of supermarkets to the smart grid demands equals 15% of the wind electricity in Germany or more than 20% of the wind electricity in the EU. Adding the potential of today's unused compressor capacity could add another 100% to the demand response flexibility in the event of overproduction of wind electricity. In connection with external thermal networks such as district heating, supermarkets may serve as storage opportunity for renewable energy sources like wind.

In Denmark, SuperBrugsen supermarkets always make shoppers feel welcome. In a local town, Høruphav, Danfoss has engineered an innovative kind of heating. Calculations show that the surplus heat from SuperBrugsen will supply 16 private homes of 130 m² annually. (Photo: Danfoss)

A GREEN MUNICIPAL APPROACH

From cost to income, benefiting city hall and citizens

Hedensted Municipality was aware that it was a waste of resources to send excess heat from the City Hall servers through the ventilation system. This made it an easier task for Cronborg to assure the municipality of the profitable and environmental advantages of buying and installing their RECOOL solution.

Hanne Kronborg, co-founder and director of Cronborg

“An interesting project was presented to us. There was a prospect of a financial saving and an opportunity to improve the municipality's climate account. It was important that we could save CO₂,” says engineer Niels Abildsten from Department of Construction in Hedensted Municipality.

Flexibility in installation and use

Cronborg has developed a new product based on existing technologies. The heat pump system, RECOOL, can collect excess heat from e.g. a server and reuse it for space heating and domestic hot water through the existing heating system of a building.

With RECOOL, Hedensted got a flexible option to use their surplus energy from cooling systems. The surplus energy can

be stored in the buffer tank and used later for space heating and domestic water. Hedensted also has the opportunity to use electricity for cooling with the heat pump when it is cheap, and save the energy for heating the building and the water when the electricity is expensive.

A good business case

The specific system in Hedensted has an annual operational cost of EUR 4,300 in electricity consumption. In turn, the municipality saves approximately EUR 14,100 on the heating bill, creating an annual operating profit of around EUR 10,000. With a purchasing and assembly price of EUR 53,600 the system has a payback period of approximately 5.5 years.

Roughly 700 kWh is generated from the servers every day. This corresponds to the daily electricity consumption of 24 households, and it provides the City Hall with 50% of its heating need during the winter months. When the outdoor temperature increases, the system provides up to 75% of the City Hall's heating.

Overall, Hedensted Municipality saves approximately 10,000 litres of oil per year. This corresponds to an annual saving of 28 tonnes of CO₂.



Photo: Cronborg

RENOVATION

The green potential of existing buildings

Around 40% of European energy consumption is from buildings - mainly for heating and ventilation. Renovation of buildings is therefore a major contributor to reduce energy consumption.

Flemming Løkke Petersen, Senior Adviser, Federation of Danish Building Industries

Why renovation?

Approximately 40% of the European energy consumption comes from buildings and the building stock accounts for 68% of total gas consumption according to the European Commission. Reducing the energy consumption, CO₂ emissions and dependence of foreign imports of energy can be accomplished by renovating existing buildings or by demolition and subsequently building new, energy-efficient ones.

New build is in general a more efficient and cost-effective way to achieve energy savings compared to renovation. The rate of new build is only in the range of ½-1% of the existing building stock per year in Europe. Therefore, replacing the existing building stock will take more than a century. Many private house owners and tenants do not have the necessary wealth or opportunity to new build and therefore only have the choice to renovate or not. This is why new build and renovation must go hand in hand when striving for higher energy efficiency and flexibility in buildings.

Huge energy efficiency potential in the building sector

The long-term economic potential of energy efficiency is huge in the building sector. According to IEA projections to 2035, more

than 80% of the energy efficiency potential worldwide, which is economically viable, will remain untapped unless current practices and policies change. This can be due to the fact that many types of renovations are of low-interest and competing with other more high-status projects - e.g. many consumers prefer a new kitchen instead of replacing the existing windows with more energy efficient ones or installing cavity wall insulation.

How to tap the energy efficiency potential

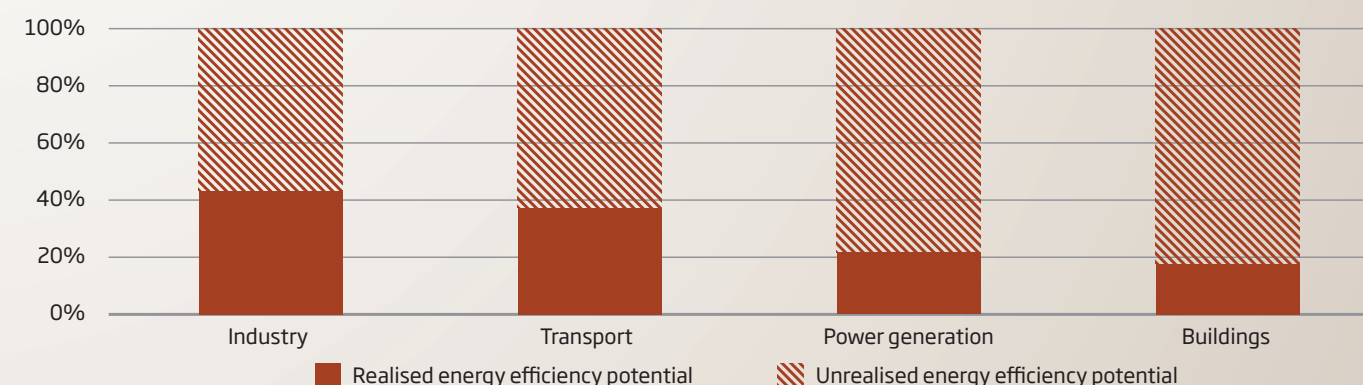
It is a great challenge for the building sector and the politicians to break through this barrier of low interest for renovation projects. There is no easy solution to the problem but one way would be to focus on the economic transparency of renovation projects.

The Federation of Danish Building Industries advocates that focusing on Life Cycle Cost (LCC) analysis can leverage a more transparent market for renovation. LCC analysis will make it easier for the customer to make the right decision based on the economic performance of the project in its entire life span. However, it is important that the LCC analyses is backed up by the right communication and marketing campaign.

Another option to tap the energy efficiency potential is that the building sector continuously develops new smart solutions for deep renovation. It is a challenge to increase productivity in the renovation sector whereby the cost of renovation can be reduced. A solution will be universal renovation kits and modular systems scalable to more and larger renovation projects. Instead of inventing the wheel over and over again, the building sector should benefit from repeating working procedures, which will cause less faults and lower costs.

Lowering the cost and improving the access to financing for building renovation will also enable further efficiency gains to be obtained. The Danish mortgage system is probably among the most effective in the world making it fairly cheap to finance renovations and today it is a source of inspiration for other countries.

Reducing the costs of deep renovation, enabling more accessible and cheaper financing and making the renovation market more transparent by using LCC are three ways to harvest the green potential of existing buildings.



Long-term energy efficiency economic potential by sector

Note: These energy efficiency potentials are based on the IEA New Policies Scenario outlined in the World Energy Outlook 2012. Investments are classified as "economically viable" if the payback period for the up-front investment is equal to or less than the amount of time an investor might be reasonably willing to recover the cost, using the value of undiscounted fuel savings as a metric. The payback periods used were in some cases longer than current averages but they were always shorter than the technical lifetime of individual assets.

Source: IEA (2014), Capturing the Multiple Benefits of Energy Efficiency.

(Photo: Skyfish.com)

PRECISE METERING PROVIDES TRANSPARENCY IN ENERGY AND WATER CONSUMPTION

Kamstrup smart metering solution supplies data for operational efficiency

In the Dutch retirement residence Amaris De Veste, focus is on sustainable energy. With Kamstrup meters and communication technology, energy efficiency is increased even further.

Jens Andreasen, Vice President Metering Services, Kamstrup

When the Housing Association Habion and the care group Amaris decided to make a huge investment in 70 new apartments in the Dutch city of Naarden, they also decided that the complex should focus on sustainable energy. Heat pumps, heat recovery ventilation and thermal energy storage therefore play an important role in the entire energy supply of the apartment complex.

With the delivery of 282 energy and water meters and an integrated communications network, the Danish company Kamstrup is involved in the Amaris De Veste project.

Operational optimisation through transparency

Transparency in the total energy consumption makes it a lot easier to optimise the energy supply in the apartment complex.

It allows for more efficient adjustment of the power generation, and the heat supply is generated more sustainably. With the solution from Kamstrup, it is expected that the energy supply becomes even more energy-efficient in the coming years.

Kamstrup takes care of the entire system operation for the next ten years. This includes collecting hourly values for heat and water meters and 15-minute values for the electricity meters. Current electricity tariffs are automatically registered in the system and can be presented to the consumers, so that they can choose to shift their electricity usage to off-peak time periods when power is less expensive. Every day, the data is exported to a File Transfer Protocol (FTP) Server operated by Kamstrup. The enormous amount of data ensures that the

energy and water supply always runs at its best – operationally as well as economically.

Involvement of end-users increases energy awareness

An extra plus is that each resident has an account, so that the end-user can see their own energy consumption in a web application. This visualises the effect their everyday behaviour has on their energy bill, and it can help them to actively reduce their consumption.

Solution

- 282 energy and water meters
- 30 rental apartments (heat and water meters)
- 40 apartments with care (heat, electricity and water meters)



Dutch retirement residence Amaris De Veste has experienced significant increases in energy efficiency after the implementation of a smart metering solution. Precise and reliable metering combined with a strong focus on data collection results in transparency that enables optimisation of the energy supply in the entire apartment complex. (Image: Kamstrup)

SMART ARCHITECTURAL RETROFITTING

Saves up to 75% energy and increases attractivity in urban historical housing areas

Historical buildings possess a huge potential for sustainable urban growth. The key is integrated design processes, connecting the technical with the cultural, as well as the environmental with the financial.

Niels Jakubiak Andersen, Associate Professor KADK, CEO Krydsrum Architects/e+

Smart architectural retrofitting solves multiple urban challenges within the same project. As the Ryesgade 30 project in Copenhagen demonstrates, it is possible to reduce energy use drastically when retrofitting a historical building, while offering increased comfort, enhanced user control of the indoor environment – and increasing availability of attractive housing in urban centres.

The results from a successful smart architectural retrofit are multiple: Cultural heritage and existing qualities of life are enhanced, property value increases dramatically and the everyday environmental footprint of use is reduced significantly.

Technical and architectural improvements

Ryesgade 30 is a common Copenhagen 5-storey 32 apartment house from 1896, which was retrofitted and completed in 2013. Four new penthouse apartments

were added as well as a total upgrade of all existing apartments including french balconies and new bathrooms and kitchens.

The building was in both physically and technically unhealthy condition, and living conditions for inhabitants were poor. However, several building features such as the significant and detailed brick façades had lots of qualities as well as the prime location and the qualities of the area around.

In order to change the living conditions of users, all year comfort levels, as well as reducing the overall energy consumption of the building, several advanced technical improvements have been integrated: Double frame low energy windows, high performance solar cell roof, compact high insulation materials for inner face of exterior walls and roof/basement, decentral low sound heat regain ventilation systems and Intelligent House Concept (IHC) to mention some of the most important.

Interplay of systems, building and people

In order to make a successful retrofit, the combination and interplay of systems must be managed carefully.

Therefore, shifting the focus from the individual component to the holistic interconnectivity between systems and people is crucial. Each individual component must be understood, implemented, used and evaluated as part of a bigger holistic whole.

The real success of such projects depends on handling the interdisciplinary work between architects and engineers, but also the administrative, legal and financial aspects, as well as the collaboration with the actual users, suppliers, developers and contractors.

Investing in the Ryesgade 30 retrofit project more than tripled the owners' yearly property profit, and it was fully rented from the beginning. It won the Danish RENOVER award for the best retrofit in Denmark in the year 2013.



The creation of new architectural values such as roof top housing within the historic areas is a strong financial driver for building owners and investors. Also, it is a very sustainable form of urban growth within the existing city and infrastructure. Culturally and aesthetically such building additions are improving the surroundings significantly if designed carefully to enhance and not obstruct existing quality of life on the street level. (Photo: Krydsrum Architects)

FROM OUTDATED TO REFURBISHED, ENERGY-EFFICIENT AND SMART OFFICE BUILDING

Extensive renovation reduces energy consumption by 85%

Sustainable housing is key to ROCKWOOL International. The company's own headquarters recently went through a serious energy efficiency overhaul.

Susanne Kuehn, PA Manager, ROCKWOOL Scandinavia

The decision to renovate

With an energy consumption of 264 kWh/m² per year there were only two options for the existing Rockwool office building of 1979: Either demolish or renovate.

"It was considered to demolish the building but as the construction is heavy concrete the environmental footprint would be better if the building was deeply renovated," explains Arne Damsgaard Olsen, Department Manager in ROCKWOOL International.

After extensive energy renovation the consumption has been reduced by 85% to 38.5 kWh/m² per year, which is below the level of the voluntary low energy class 2015 in the Danish Building Regulation (41 kWh/m² per year). Demolishing and constructing a new office building would have increased the cost significantly compared to the energy renovation project.

Upgraded energy performance

The aim of the renovation has been to

upgrade the energy performance to meet standards and not least to make first class work places.

The first step was to reduce the energy loss from the building by improving the building envelope with new and better insulated façades and more insulation towards the parking deck under the building, as well as new windows.

Another contributor to a low energy demand is LED electrical light and an effective mechanical ventilation system with heat recovery. This has been supplemented by natural ventilation in the top of the building.

Next step: smart solutions for energy supply

Having reduced the overall energy loss and energy demand of the office building, the next step to an energy-efficient building is smart solutions towards achieving the energy supply.

The demand for heating is met by geothermal heat pumps and as one of the first cases in Denmark it is with vertical wells. The hot water supply is partly covered by heat collectors on the roof, and the electricity use is to some extent supplied by photovoltaic (PV) solar panels on the roof.

The energy production by heat pumps, solar collectors and PVs is measured on a monthly basis and so is the consumption for all three demands: heat, hot water and electricity.

This control is already carried out by an Energy Management System (EMS) and in the near future production and consumption will also be balanced through smart management with this system. With minor adaptations, the EMS system can be integrated in a demand response market by delivering flexibility.

Solution

- New façades with Rockwool-FlexSystem
- Extra Hardrock insulation in the parking deck
- New 3 layer windows
- LED electrical light
- Mechanical ventilation with heat recovery and cooling
- Natural ventilation in the top of the building
- Heat pumps with 150 meter deep wells
- 3 kWh/m² year heat collector for hot water
- 17 kWh/m² year PV production
- The renovated building will be EEC-ECO-Life certificated



Rockwool International office building was recently renovated to upgrade energy performance. The building envelope was improved with new and better insulated façades and new windows. Also, heat collectors and PV has been installed on the roof for energy production. (Photo: ROCKWOOL)

ONE FAMILY HOME: MAISON AIR ET LUMIÈRE

A Model Home 2020

Model Home 2020 is an experiment launched by the VELUX Group as part of the strategy to take an active part in developing sustainable buildings for the future.

Catherine Juillard, Institutional Relations and Sustainable Buildings, VELUX France

Maison Air et Lumière is based on the Active House principles and built on a vision of creating a house with a positive energy balance and a neutral environmental impact, with the living conditions of the residents at the focal point. Thanks to the ingenious use of its pitched roof, the house provides both a pleasant living environment and energy efficiency. The key to its architectural design is the different roof pitches that boost the building's potential to capture solar energy, turning it into a home with a positive energy balance. Air and daylight infuse the entire space, creating a healthy indoor environment.

The house, which is situated at Verrières-le-Buisson, a green oasis close to Paris, is part of the Europe-wide VELUX Model Home 2020 project. Once completed, its occupants gave feedback on their experiences of living in the house, and energy

performance data was also collected as a basis for research into the sociological and scientific aspects of sustainable living.

Ventilation and daylight at the heart of comfortable living

By clever use of the space under the roof, the architect has created a habitable area of 130 m² over two levels with an intermediate level between the garden level and the upper floor. The home was designed to capture natural light from all directions: southern light, northern light and top light. Creating balanced light throughout the house, this makes for a pleasant and healthy living environment.

The architectural design greatly facilitates natural ventilation, which, when the season and the weather require, is enhancing double-flow mechanical ventilation. In the summer months, an intelligent control

system opens windows and deploys sun screens to regulate the indoor temperature and ensure optimum comfort.

Energy efficiency

The energy efficiency derives from the maximum insulation of the house combined with the optimised capture of sunlight through the windows, reducing heating demand to a minimum. The energy concept of the house is based on the maximum use of renewable resources: solar energy, natural light and fresh air.

Heat and domestic hot water are provided by a heat pump connected to thermal solar panels and a low-temperature underfloor heating system. All residual energy consumption is provided by the photovoltaic panels integrated into the roof, resulting in a positive energy balance.



(Photo: Adam Mørk)

Working with Sustainable Living in Buildings can benefit society at large through increased productivity, improved learning abilities and reduced health costs. Therefore, the VELUX Group takes active part in this transition by engaging with stakeholders in the building industry, initiating experiments and offering high-quality roof windows that enable people to live healthy and comfortable lives, while maintaining a good energy balance of the building.



(Image: Adam Mørk)

The architecture of Maison Air et Lumière is adapted harmoniously to its site - revolves around natural light and ventilation. Carefully-positioned façade and roof windows bring in sunlight from all directions to bathe the interior with a balanced, natural glow.

AN INTELLIGENT APPROACH TO SUSTAINABLE BUILDING DESIGN

Thinking smart in the design phase

Smart buildings require intelligent design. The architectural design of a building is the key to superior building performance.

Peter Andreas Sattrup, Architect MAA PhD, Chief Advisor Sustainability, Danish Association of Architectural Firms

The case for architectural design

We are surrounded by design. Some of it smart, some of it less so. Think of your city. Its layout and planning will affect your need for a car, and the design of your car will in turn affect your demand for energy. The same thing is true for buildings. Intelligent design is the first requirement for great performance and enhanced experience.

Every building project is an exercise in resource management, and its architecture an expression of how this challenge is resolved. An excellent building offers a productive, enjoyable environment to its users, while effectively managing the economic resources invested in it - not least through superior performance on indoor environment and energy use.

Danish design & know-how

50-75% of a building's energy demand is decided by architectural design. Its orientation towards the sun, the availability of daylight, the design of its structure and façade, the choice of glazing and insulation all work together with the building services and control systems to produce a great

environment. You can think of architecture as a way to increase social and cultural benefits by integrating and calibrating smart technical solutions on many scales. The result is greater than the sum of parts.

Denmark was the first country to implement voluntary near zero energy classes in its building regulations, gradually making these mandatory over a decade. The consistency of this policy allowed (and pushed) architects, engineers and the entire Danish construction sector to innovate in know-how and technology across the entire value chain, with the result that Danish expertise is now highly valued abroad.

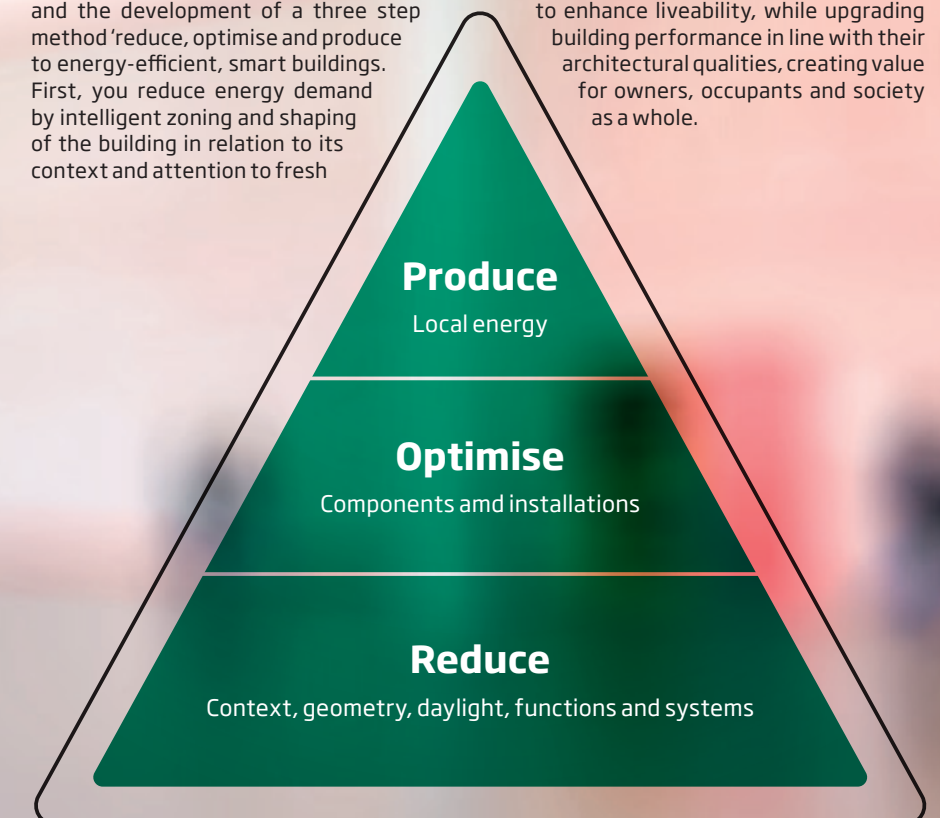
Design methods for smart buildings

An example of this is Henning Larsen Architects where investments in research have led to innovation in design methods and the development of a three step method 'reduce, optimise and produce' to energy-efficient, smart buildings. First, you reduce energy demand by intelligent zoning and shaping of the building in relation to its context and attention to fresh

air, sun and daylight availability in the design of façade openings and interior spaces. Next, you optimise building services and smart control systems enhancing the indoor environment and reducing the energy demand further. Finally, once the architectural design and integrated engineering has reduced demand to an absolute minimum, it is possible to integrate renewable energy systems that may produce energy, possibly making the building energy positive.

Retrofits and upgrades

Similar approaches can be seen targeting the huge challenge of retrofitting and upgrading existing buildings. In Denmark, a forecast predicts the construction market to move from a 50/50 to a 10/90 ratio of new-build to retrofit projects. Integrating intelligent technical solutions in historic building districts and buildings is a way to enhance liveability, while upgrading building performance in line with their architectural qualities, creating value for owners, occupants and society as a whole.



A SUSTAINABLE MUSEUM WHERE NEW AND OLD UNITE

Daylight and technology as a design strategy in sustainable building design

Sustainability has been a guiding parameter in the overall architectonic arrangement of Moesgaard Museum as well as the technical design of the building.

Signe Kongebro, Partner and Manager of the Sustainability Department, Henning Larsen Architects

Uniquely located in a hilly landscape with sloping roofscape of grass, moss and flowers the new Moesgaard Museum has become a powerful landmark designed by Henning Larsen Architects.

The museum is sustainable by design, meaning that the work around architecture, space and daylight is combined with evidence-based design strategies and modern energy technology.

Designing with daylight

The compact building volume integrates into the landscape, thereby preserving the existing green area. The rectangular,

sloping roof, oriented towards the south, reduces the façade area and brings daylight through the rising northern end façade and the façades facing east and west. Thereby, an optimal use of daylight in the museum has reduced the need for artificial lighting.

Besides being an excellent example of unifying landscape and architecture, the green roof also reduces the overall need for cooling due to decreased heat absorption and transforms CO₂ and other exhaust gases to oxygen, improving the environmental footprint of the building. Furthermore, the overall amount of wastewater run-off from the site is reduced.

The overall sustainable strategy has been integrated in the architectural design. Fundamental elements such as the building's geometry and orientation have been considered in order to maximise every square metre. The south-facing roof surface (roof façade) forms the calculated basis for an energy-efficient building, which achieves Energy Class 1 status, according to the Danish Building regulations. A series of energy-saving measures have been implemented to minimise the building's overall energy consumption.

Energy Management System (EMS) controls energy consumption

But the museum is not only an example of smart architecture. SE Energy & Climate has mounted modern automatics for controlling and managing temperatures, CO₂ emissions, air humidity, light, alarms and more in the building.

The Intelligent Buildings Installation (IBI) contains light regulation, daylight regulation, presence-regulation, heat controlling, and ventilation controlling together with energy data collection from the gauges.

A dynamic platform easy to use and adaptable to changes

From the beginning SE Energy & Climate has focused on providing user-friendly solutions, making it easy for all types of clients to use. Giving the clients clear manageable graphical systemic illustrations, the clients can easily foresee operations conditions and regulate it online.

An essential but difficult variable to account for in the equation of energy consumption is human behaviour. Another unknown factor is the weather.

Besides being able to encounter internal factors, such as human behaviour, the system can also encounter external factors, such as weather data or energy prices. Thereby the Moesgaard Museum is ready for future demands.

– Jesper Klitgaard Frederiksen, Director, IBI, SE Energy & Climate



Photo: Jan Kofod Winther

Up to 50% savings in energy consumption

EMS systems are an effective way of managing different systems in a building. It is a management system that continuously secures a low level of consumption. The EMS that SE Energy & Climate has provided for Moesgaard Museum in cooperation with Lindpro means cost savings up to 50% on electricity, water and heat. The payback time is often only a few years and in an addition to the direct economic measures there are many indirect savings like less service expenditures and less renewals – for example in light sources.

THE SUNHOUSE - AN ACTIVE HOUSE FOR CHILDREN

A new standard for use of daylight and fresh air in pedagogical environments

Solhuset (The Sunhouse) is the most climate friendly daycare centre in Denmark and contributes to both the environment surrounding it, as well as to the health and comfort of the children using it.

Kurt Emil Eriksen, Senior Political Advisor, VELUX Group

Childcare centres and schools have a particular need for a good and healthy indoor climate as it strengthens well-being and learning capacity as well as reduces the risk of diseases for the users. The vision for Solhuset was to set new standards for future sustainable childcare centres. It rests on the Active House principles of buildings that give more than they take – to the children, adults, environment and surroundings.

Solhuset has been a project founded in a public-private partnership between Hørsholm Municipality, VKR Holding A/S and Lions Børnehuse, and it is built by Hellerup Byg A/S in co-operation with Christensen & co arkitekter a/s and Rambøll A/S. It is a unique building, self-sufficient with energy, with a healthy indoor climate and it is built as an Active House.

Daylight and fresh air

Giving plenty of daylight and fresh air to the children in daycare was a central part of the strategy for securing a healthy and good indoor climate.

To live up to this goal, Solhuset was designed with high-ceilinged rooms and strategically placed windows to ensure optimum use of daylight. The sloping roof and the roof windows that open and close automatically create varied ceiling heights for good air circulation in the rooms.

Use of renewable energy

Solhuset uses renewable energy sources and is designed to produce more energy than it consumes.

The sun supplies Solhuset with heat through the roof and façade windows. The windows contribute half the heat needed in wintertime. The remaining requirement for space heating and hot water is produced by a combined solar and geothermal system. Strategically placed on the south-facing roof, 50 m² solar collectors harvest energy directly from the sun and convert it into heat and hot water, while 250 m² solar cells convert solar energy into electricity. Solhuset was designed to produce 9 kWh per m²/year more than it is expected to consume.

The surplus energy production means that in about 40 years the centre will have paid back the CO₂ emitted during production of its primary building materials. That makes Solhuset CO₂ neutral throughout its lifetime.

Living with nature

Solhuset contributes positively to its surroundings and interacts with nature. The childcare centre is an open and transparent building with seamless transitions between functions and between outdoors and indoors. It was designed, located, and constructed to let in nature and create closeness between indoors and outdoors.

The shape, orientation and windows are optimised in relation to the plot as well as the sun in order to make maximum use of daylight and solar heat. Solhuset is triangular, like the plot it is built on, and the roof surfaces face north and south. The south-facing surfaces are steeper than those facing north to obtain the optimal angle to harvest solar energy.

Architecture: Christensen & Co
Photo: Adam Mørk



The childcare centre has a healthy indoor climate with fresh air and 3.5 times more daylight than required by current building regulations.

The childcare centre is CO₂ neutral in its lifetime and self-sufficient in energy through passive solar gain from windows, solar collectors, solar cells and geothermal pipes.

The building was designed to meet the requirements of Danish energy class 2015 (51 kWh/m²/year) even before use of renewable energy sources.

In February 2011, the integrated childcare centre Solhuset in Hørsholm opened its doors to nearly 100 children and 30 adults. They now enjoy life in a healthy environment with plenty of daylight and fresh air.

GREEN HOTEL BENEFITS FROM EFFICIENT PUMP TECHNOLOGY

Smart Grundfos pumps contribute to energy saving in heating and cooling

At first sight the 85 metre tall, black luxury hotel does not look particularly green, but the Crowne Plaza Copenhagen Towers sets new standards for sustainability and low energy consumption.

Jens Nørgaard, Senior Manager, Building Services Applications, Grundfos

The Crowne Plaza Copenhagen Towers is not just an architectural landmark and a world class luxury hotel. It is a visible demonstration of comfort walking hand in hand with sustainable solutions, and since the opening in 2009, it has received a vast number of awards and recognitions for its path-breaking innovative construction. Among these was the Skål International 2010 EcoTourism Award for the project World's Greenest Hotel.

Advanced energy storage

An exceptionally low energy consumption in the hotel's heating and cooling systems reflects the energy efficient approach. Thanks to one of the world's most advanced Aquifer Thermal Energy Storage (ATES) systems, the total annual energy consumption is very low. The consumption for central systems for heating, air conditioning and ventilation is only 51 kWh/m² for heating, air conditioning and ventilation.

The ATES system, located in the basement of the Crowne Plaza, covers up to 60% of the building's total cooling need, and as a "free" cooling process it supplies cold groundwater for guest room cooling during the summer. The cold groundwater circulates through an exchanger that cools water in the hotel's hydronic air conditioning system. In this process, the groundwater heats up and subsequently is stored in another well, so that it can be utilised for room heating during the winter.

Short payback time

The extra investment in the ATES system really pays off. It has a projected payback time of between six and seven years. This means that the Crowne Plaza Copenhagen Towers is greener as well as more profitable than its competitors in the long term.

Combined with a Variable Airflow Volume (VAV) ventilation system, the ATES system

ensures individually cooling, heating and ventilation of guest rooms and lobby as well as conference facilities in accordance to the demand at any given time. The system performs 4.1 MW cooling and 2.4 MW heating, and ensures particularly low costs for air conditioning and heating, compared with other hotels.

Efficient pumps

All Heating, Ventilating and Air Conditioning (HVAC) pumps in the building are from Grundfos. They contribute to considerably reduced energy consumption in all systems for air-conditioning and heating. The pumps are very energy efficient on their own, and all of them are equipped with frequency converters in order to make them able to adapt variations in flow requirements – and thus further contribute to energy savings.

The hotel's projected energy consumption is 51 kilowatt-hour per square meter for heating, air-conditioning, and ventilation. For an average European four-star hotel, the energy consumption is about 300 kilowatt-hour per square meter. The two figures can however not be compared directly, as the figure for the Crowne Plaza Copenhagen Towers – contrary to the average figure – does not include decentralized devices, connected to plugs. The size of this part in the average figure is not known.

The calculated payback time for the ATES system is six to seven years.



Photo: Grundfos

DENMARK - THE STATE OF GREEN

Denmark has a long tradition for energy efficiency improvements and renewable energy. In order to harness the full potential of the increased share of renewables, energy must be used more efficiently, effectively, and intelligently. Flexible consumption and a smart energy infrastructure must be developed to meet the challenge of fluctuating energy sources. Buildings play a crucial role in this process.

Denmark knows smart energy and energy efficiency

In Denmark we believe that knowledge is power. To ensure that the transition to a greener economy is a good investment, renewable energy resources must be intelligently integrated into the energy system. This requires more flexibility in the system, partly enabled by smart buildings, strong interconnectors and market coupling throughout the region.

Since the 70s, Danish governments have addressed the country's limited natural resources, concentrating on using them wisely, pushing energy efficiency measures. As a nation we are known for our ability to

collaborate and our expertise is in helping customers and stakeholders reach highly efficient and 'smart' solutions, while in turn developing their ability to profit from that knowledge. We see great opportunity for mutual benefits in the transfer of knowledge, spurring growth in both partners' businesses - holistically, with healthy respect for different perspectives and agendas, as well as for the environment.

Explore, learn and connect online

State of Green gathers all the leading players within smart energy and energy efficiency in Denmark. Stateofgreen.com is the official platform for Denmark's green solutions and knowhow. The web portal is an online entry point for all relevant information about Danish companies and institutions and their expertise within intelligent energy and energy-efficiency in Denmark's eight other green strongholds.

Come visit us in House of Green

House of Green is an interactive visitors' and exhibition centre located in the heart of Copenhagen. House of Green uses a combination of guided storytelling and

self-exploration to showcase green Danish integrated solutions and scenarios, as well as an overview of the combined Danish story within energy, climate, water and resources. Danish representatives act as hosts that both inspire and inform delegations before they move on to on-site visits. For more information about House of Green, please visit www.houseofgreen.com.

Experience implemented green solutions - live!

A cornerstone of the Danish vision is to inspire others and demonstrate how a green society is both possible and profitable - and we invite people to come see for themselves. Through State of Green Tours we offer commercial and political decision makers and journalists from around the world a chance to take advantage of the lessons learned by leading Danish companies and institutions within the fields of energy, water, climate adaptation and environment, and to experience Danish green solutions - live. For more information about State of Green Tours, please visit www.stateofgreen.com/tours.

SMART BUILDINGS - WHY AND HOW

Increasingly global questions. Denmark has quite a few answers.



Lars Chr. Lilleholt, Danish Minister of Energy, Utilities and Climate

Wasting energy was never a good idea. But there was a time when we knew neither how to eliminate such waste nor the cost of it. This includes, as we know now, not only the direct cost of unnecessary spending on fuel and power plants, but also consequences like health costs due to pollution, the cost to treasuries subsidising fossil fuels or the mounting costs of global warming.

Many have discovered that buildings are an excellent place to start cutting these costs. In the world's most energy consuming countries, the building stock is the most voracious consumer - bigger than industrial processes or transportation. And the potential for smarter and leaner use of energy is huge. While there is no such thing as a zero-energy commercial airliner or a zero-energy cement plant - not even on an experimental basis - zero-energy buildings are already old hat.

The market for energy efficiency is fast on its way from being a niche market to a well-established market with a huge potential. According to the International Energy Agency (IEA), the global energy efficiency

market is worth at least USD 310 billion a year and growing fast. This presents major economic opportunities.

All over the world, businesses and governments have started acting on this. Many countries have introduced minimum standards for energy efficiency. Not only US and EU member states, but also many emerging economies, including China. And businesses have responded by innovating and competing to provide more efficient solutions. In many areas, this has brought spectacular results - more efficiency sooner, and at a lower up-front price than we had expected. Denmark is at the forefront of this revolution. Our minimum standards for building energy efficiency are the world's most demanding. And Danish businesses operating in the field are equally world class.

But smart buildings can do more than reduce energy costs. While some buildings are loved by their users, others are hated. Quite often, this is a result of building design. The economic implications may be huge - not only for rents or sales prices but also in terms of

employee efficiency and absenteeism. So, truly smart buildings are also attractive. And Danish architects keep winning international competitions at a rate quite disproportionate to the small size of our country. So it seems they must know a thing or two about attractive designs.

Last but not least, smart buildings can increase efficiency and reliability in the overall energy system, storing energy when it is abundant, and then releasing it and shutting down non-essential consumption when demand is high. Obviously, this can reduce peak loads, the need for generation capacity and the risk of blackouts. This may be worthwhile in any energy system. But it is particularly helpful, when intermittent wind or solar generation account for a large share of total capacity. In Denmark, this share was 40% in 2014 and it will be more than 50% in a few years. Nevertheless, blackouts are virtually non-existent, and this is another area where Danish expertise is state-of-the-art.

Lars Chr. Lilleholt

About State of Green

State of Green is a public-private partnership founded by the Danish Government, the Confederation of Danish Industry, the Danish Energy Association, the Danish Agriculture & Food Council and the Danish Wind Industry Association. H.R.H. Crown Prince Frederik of Denmark is patron of State of Green.

As the official green brand for Denmark, State of Green gathers all leading players in the fields of energy, climate, water and environment and fosters relations with international stakeholders interested in learning from the Danish experience. Connect through: www.stateofgreen.com





Learn more about Danish solutions in intelligent energy, find more cases from around the world and connect with Danish expertise at:

www.stateofgreen.com/intelligent-energy

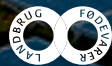
State of Green is a non-profit, public-private partnership founded by:



Confederation of Danish Industry



DANISH
ENERGY ASSOCIATION



Danish Agriculture
& Food Council



DANISH WIND
INDUSTRY ASSOCIATION



MINISTRY OF BUSINESS AND GROWTH
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DANISH MINISTRY OF ENERGY,
UTILITIES AND CLIMATE

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